

# Big Urban Data

## A Strategic Guide for Cities

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Climate Change and Sustainable  
Development Sector

Housing and Urban  
Development Division

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2019



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# BIG URBAN DATA

## A STRATEGIC GUIDE FOR CITIES

### ABSTRACT

This technical note provides guidance to help municipalities improve city governance through the use of *big urban data*, which we define as the collective body of information on assets and activities in cities. Our analysis of Latin American and Caribbean cities shows that the application of big urban data is not yet widespread, despite its potential to improve the efficiency and quality of urban services. Furthermore, the significant risks of mismanagement of data initiatives, from politicization to privacy breaches, are not yet well understood within urban governance. We present a new tool, the *big urban data maturity model*, which empowers cities to assess their competency across five functional areas: open data, data ecosystems, analytics, data-driven decision-making, and digital city services. We also identify specific steps that can be taken to improve governance. Finally, we offer a set of organizational and financial recommendations that can help municipalities institutionalize big urban data practices by following best practices in open data and the participatory coproduction of city services.



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# 01

**BID URBAN DATA**  
A Strategic Guide for Cities

# WHAT IS BIG URBAN DATA?

| 2 | 3 | 4 | 5

The spread of computation from desktops to mobile devices is now permeating the entire human-made environment. Buildings, vehicles, infrastructure, and manufactured products can detect and analyze the world around us through the use of chips and sensors. These readings pile up every day by the terabyte, providing a rich lexicon of raw information about life in our cities—where, by the end of the century, over 80 percent of all people on Earth will live.<sup>1</sup>

This *big urban data*, the collective body of information on assets and activities in cities, surpasses in volume, variety, and velocity the traditional statistics and administrative records city governments have used for a century to understand the present and plan for the

future.<sup>2</sup> It is also far more exhaustive, representing entire populations or systems, as well as more fine-grain, describing events and individuals in stunning detail. And it is relational, containing metadata (data that describes the data itself) that makes it easy to aggregate multiple sources of information about the same phenomena.<sup>3</sup>

Big data can be described as “traces of human action picked up by digital devices.”<sup>4</sup> Examples of big urban data in use today include: high-resolution time-series satellite images of metropolitan areas; health care records for an entire city’s population; or location records of mobile phones in a given urban area over an extended period of time.



## THE COSTS AND RISKS OF BIG URBAN DATA

Municipal governments see many opportunities to increase efficiency and quality in the delivery of services, expand transparency, and improve forecasts and long-range plans.<sup>5</sup> Chicago worked with data scientists from Allstate Insurance over a four-year period to create a predictive model combining existing data sets to target food safety inspections on the most likely violators.<sup>6</sup> New York previously used this approach to focus fire safety efforts on the highest-risk buildings.<sup>7</sup> São Paulo and Rio de Janeiro partnered with Google's Waze to improve traffic forecasting with real-time crowdsourced data

provided voluntarily by millions of drivers.<sup>8</sup> Other cities are exploring ways to apply big data approaches to tougher policy challenges in public health, social services, and education.

But big data has risks. “Raw data is both an oxymoron and a bad idea,” argues informaticist Geoffrey Bowker. “To the contrary, data should be cooked with care.”<sup>9</sup> The amount of effort required to extract value from data and the risks of improper handling and analysis are taken too lightly. Few have the will or capacity to systematically evaluate the broader, long-term institutional impacts of large-scale data-driven management in government. Many organizations overestimate the power of data analysis, using it to justify decisions already made by political and organizational processes.<sup>10</sup> These attitudes prevail despite the considerable and growing body of evidence showing how these practices distort incentives and encourage manipulation of what data is recorded and how it is coded and classified in ways that produce suboptimal and even outright discriminatory policy outcomes.<sup>11</sup> The largest set of risks revolves around privacy. City governments col-

lect significant personally identifiable data in their day-to-day operations—facilities and infrastructure, public service and benefits delivery, law enforcement and judicial administration, and taxation and licensing. Public concern over this data gathering depends on the depth of personal information required and the degree to which it is perceived to enhance service delivery or merely enable surveillance.<sup>12</sup> For instance, Zaragoza, Spain has introduced a smart “citizen card,” which stores individual information and allows citizens to access and pay for 20 urban services.<sup>13</sup> The card has not raised substantial privacy concerns, an attitude that researchers link to its perceived function as a secure payment system, the existing trust between citizens and government, and the small amount of personal data actually stored in the card (even though the card's use creates a substantial trail of linked transaction records).<sup>14</sup> In contrast, in Toronto, the future of tech giant Alphabet's ambitious Sidewalk smart city project, “Quayside,” is in jeopardy in large part because of potential issues with privacy and participation, and a failure to include key community stakeholders in developing its data governance framework.<sup>15</sup>

# TOWARD DIGITAL MASTER PLANNING: A BIG DATA MATURITY MODEL FOR CITIES

Growing awareness of the complex tradeoffs involved in extracting value from big urban data reflects a broader evolution in the smart cities movement. Cities are thinking more strategically, and many are investing time and energy in the development of *digital master plans*. These efforts showcase an emerging strategic practice aimed at aligning cities' many technology specific and data-enabled initiatives with existing goals, strategies, and programs. Digital master plans help cities define basic principles, desired outcomes, stakeholders, processes for engagement and deliberation, and approaches to implementation.<sup>16</sup> In this technical note, we offer a tool for cities to assess their state of readiness for data-enabled governance: the *big urban data maturity model*. This tool draws inspiration from Dublin's "Digital Maturity Scorecard," published shortly after the city's digital master plan in 2014.<sup>17</sup> Dublin and other cities offer valuable lessons for municipal leaders. In Section 2, we

analyze recent experiences from Latin American and Caribbean cities and highlight two defining trends in data governance: the gradual adoption of open-data principles throughout the region, and a growing commitment to the participatory design and delivery of infrastructure and services, i.e., the coproduction of urban services. Section 3 introduces the *big urban data maturity model* and explains how cities can use it to self-assess across five key functional competencies: **open data, data ecosystems, analytics, data-driven decision-making, and digital city services**. We provide details on each of these elements and illustrate how municipal leaders can use the model to track progress over time.

Overall, our goal is to provide a common tool to focus cities' future efforts to create, leverage, and govern big urban data. But we also see an opportunity for cities to rehearse the self-assessment, which can later be applied to more robust digital-master-planning efforts in support of comprehensive smart city visions. To help jumpstart this longer-term planning process and to show cities how to "move up" in data maturity, in Section 4 we provide a set of strategic actions to institutionalize successful big data innovations—by generating revenue, by designating leadership, and by adopting rules and norms that establish democratic authority for data innovation.



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# 02

**BID URBAN DATA**  
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# HOW ARE CITIES USING BIG URBAN DATA

IN LATIN AMERICA AND THE CARIBBEAN?

1 | 3 | 4 | 5

## THE USE OF BIG URBAN DATA IN LATIN AMERICAN AND CARIBBEAN CITIES

Over the past five years, Inter-American Development Bank (IDB) has led a series of studies and programs focused on the use of technology and data for city development. This work allowed us to identify numerous municipal leaders in the region currently implementing big data initiatives in a variety of urban governance areas. We relied especially on the subset of municipal governments that participated in IDB's 2015 Gobernarte Award, which included a category focused on "Cities and Big Data." Organized annually by the bank, Gobernarte is an annual, region-wide prize for innovation in public management. The 2015 edition presented us with a unique opportunity





(and a region-wide sample of 45 cities) to learn more about a diversity of approaches to big data innovation among urban governments in the LAC region. Two municipalities in Brazil won: Fortaleza, for its use of big data in the transport sector, and São Bernardo do Campo, for implementing a digital platform to handle citizen service requests.

To complement this sample, we considered the 2016 IDB monograph *The Road toward Smart Cities*, which profiles 8 cities in LAC as well as 16 others worldwide that have deployed technology solutions to reduce costs and improve efficiencies in select urban services.<sup>18</sup> We also studied the experience of municipalities that participated in IDB's Emerging and Sustainable Cities Initiative, through which more than 70 cities in the region developed and deployed granular data on the impacts of climate change and on historic urban growth.<sup>19</sup> In addition, the 2018 IDB technical note *Los datos abiertos en América Latina y el Caribe*, a study that makes the policy and development case for open data among national and subnational governments, provides brief studies of cities that have enabled active participation and transparency through open-data platforms and pilots.<sup>20</sup> The main insight from

the study of this LAC-specific sample was that the use of big urban data is not yet widespread, but there is growing recognition of big urban data's potential. According to the Urban Institute, "The institutional arrangements that will allow city leaders to use data effectively remain incompletely theorized and poorly articulated."<sup>21</sup> Often, potential big data innovators inside government do not receive the required permission to unlock value from big data, or are not properly incentivized to do so. Yet, while there may not be an ideal case study for impact-evaluation analysis, various cities in the region have made considerable progress along one or more dimensions of big data implementation, from the development of IT architectures to the attraction and training of human talent. In other words, LAC cities find themselves at a variety of *maturity* levels in several different areas of governance.

In fact, the case studies reveal an emerging big urban data innovation landscape in the LAC region that broadly tracks international trends but is diverging in two important ways. These unique characteristics offer opportunities to positively shape big urban data innovations in the Latin American and Caribbean region—and inspire new approaches elsewhere.



# BUILDING ON OPEN DATA

First, LAC cities can build big urban data innovation on a robust foundation of open data.

Open data is widely recognized as a key catalyst for city governments to develop an institutional culture that values data as a tool for innovation. According to the global Open Data Charter, cities should strive to make data open by default, timely and comprehensive, accessible and usable, comparable and interoperable, and to use it for improved governance and citizen engagement as well as for inclusive development and innovation.<sup>22</sup> Open data also “provides ample oppor-

tunity to assess data availability and quality and to become more familiar with data previously in silos and file drawers. Opening and sharing data can accelerate its use for analytics, management, and resource allocation.”<sup>23</sup> In the LAC region, numerous national and urban governments have embraced open data substantially beyond peers at similar levels of development. This open data infrastructure has provided crucial support for the proliferation of public innovation labs in LAC cities in recent years.<sup>24</sup> Labs are important new institutions for fostering talent, advocating for open data, and nurturing a culture of data innovation.

HOW ARE CITIES  
USING BIG  
URBAN DATA  
IN LATIN  
AMERICA AND  
THE CARIBBEAN?







## ENABLING THE COPRODUCTION OF URBAN SERVICES

Second, cities in the LAC region often **mobilize big data initiatives to ensure direct participation in the design and delivery of services.** While the traditional approach to deliver urban services and infrastructure is unilateral (government entities and their partners design and deliver to “passive” citizens), a new model has emerged thanks to the ubiquity of data. Citizens are the main producers of data used for public services and, through direct digital platforms for engagement and open sharing of information, they can also have a direct role in how cities perform their functions. As a result, LAC cities can embrace the concept of **coproduction of urban services:** active collaboration between citizens and municipal governments

to plan, design, deliver, and evaluate urban services and infrastructure. This nascent approach builds on a longer LAC tradition—the promise of a rights-based approach to urban economic development, which came to prominence in the 1990s, contributed to the landmark adoption of Brazil’s 2001 City Statute that codified many of the movement’s principles into law, and is now a core tenet of urban policy in countries such as Colombia and Ecuador.<sup>25</sup> The coproduction approach in big data innovation in LAC cities is evident in the way big data’s public benefits are being pursued. The demands for greater transparency that drive the open-data movement stem directly from one of the movement’s core concerns—the ability to access resources and services. Open data is also a powerful use case and catalyst for the kinds of commons-cultivating strategies widely employed in rights-based urban governance. Initiatives that seek to improve the efficiency of urban services tend to come from the public transportation sector, which delivers the biggest benefits to the largest number of people, with disproportionately more benefits for



the most vulnerable and dependent groups. Finally, the coproduction approach requires deliberation and time, i.e., continuous innovation in urban governance, as opposed to disruptive, “move fast and break things” change.<sup>26</sup> This approach is consistent with a rights-based view that seeks to remake the city in a participatory fashion and counters the potential for knowledge inequality that can stem from increasingly consolidated management of data generated by the common citizen.<sup>27</sup> Indeed, information asymmetries present a challenge to coproduction, particularly due to another unique aspect of the LAC region—the power that utility providers and third-party infrastructure vendors hold over city governance. These organizations are disproportionately powerful in the region’s cities, as they hold the key to precious data on energy, water, transportation, and other urban services. Including them as active partners for data-driven governance, with the city functioning as data broker between multiple stakeholders, is key to a more inclusive and equitable digital age.





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# 03

**BID URBAN DATA**  
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# ASSESSING YOUR CITY'S COMPETENCY

As cities in the LAC region seek to create value from big urban data while managing its risks, what institutional capabilities and resources do they need? How can they measure their current state of readiness and plan first steps to increase capacity and take action?

## THE BIG URBAN DATA MATURITY MODEL

To support city leaders in this effort, we developed a diagnostic and strategic tool: the *big urban data maturity model*. This tool organizes city government capabilities into five key functional areas:

- 1 SHARING OPEN DATA
- 2 CULTIVATING AN ECOSYSTEM OF EXTERNAL DATA SUPPLIERS AND USERS
- 3 ANALYZING DATA TO CREATE NEW INSIGHTS
- 4 USING THOSE INSIGHTS EFFECTIVELY IN DECISION-MAKING
- 5 ENABLING IMPROVEMENT IN CITIZEN SERVICES





## WHAT IS A MATURITY MODEL?

Maturity models are widely used in information technology and management consulting to define best management practices in a given area, including key technical capabilities required at a certain maturity and how they should be used.

The purpose of the maturity model is to provide a yardstick for cities to assess themselves and an aspirational development path to pursue in order to achieve improved governance and desired outcomes.

While maturity models can be criticized for overly prescribing a single evolutionary path when more diverse strategies may exist, the advantage of the maturity model is that it provides an external benchmark.

In the following pages, we illustrate the main components of the big urban data maturity model.



# THE MODEL'S FUNCTIONAL COMPETENCIES

The big urban data maturity model defines five functional competencies that a city's broader governance system (beyond just the municipal) government must possess to use big data effectively, ethically, and equitably.

- 1

OPEN  
DATA




Supplies the underlying raw data and generates demand for data-driven governance.
- 2

CULTIVATING  
DATA  
ECOSYSTEMS




Involves creating user communities, data-sharing mechanisms, and a culture of use that pervades stakeholder networks.
- 3

ANALYTICS



Includes the core technical capacity to transform, summarize, and visualize data to obtain new, valuable insights.
- 4

DATA-DRIVEN  
DECISION-MAKING



Covers the individual skills, institutional practices, and forward-thinking culture needed to systematically use data to improve policy, actions, and outcomes.
- 5

DIGITAL CITY  
SERVICES



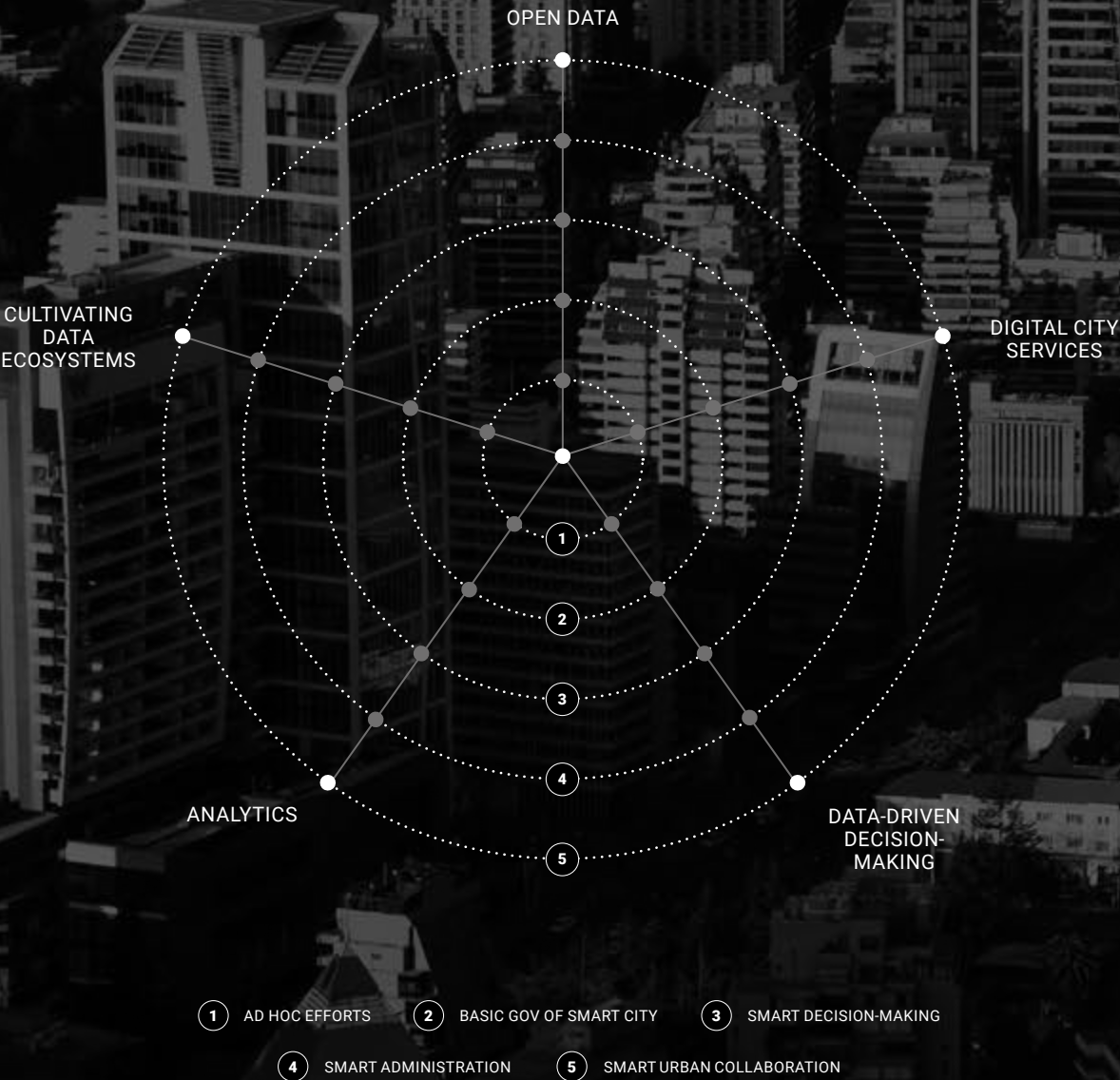
Involve the use of data to drive distributed open innovation by many actors to improve the way government and citizens interact in the public sphere.





# FIVE MATURITY LEVELS

The maturity model defines big data capabilities for urban governance systems at five benchmark levels, four of which correspond to the degrees of smart city governance defined by Meijer and Bolivar in 2016 and with an “ad hoc” level that describes many of the uncoordinated, early stage yet high-potential initiatives seen in LAC cites.<sup>28</sup> These five levels refer to:



- 1

**AD HOC EFFORTS**  
*Ad hoc efforts, typically led by individuals without necessarily producing a direct effect on how organizations operate.*
- 2

**BASIC GOVERNMENT OF A SMART CITY**  
Involving any deliberate institutional use of data beyond ad hoc actions.
- 3

**SMART DECISION-MAKING**  
Whereby individual departments use data and technology to inform their actions.
- 4

**SMART ADMINISTRATION**  
Which extends this approach throughout government.
- 5

**SMART URBAN COLLABORATION**  
Which uses technology to democratize priority setting, innovation, and governance.

It is important to note that while the academic literature prescribes attainment of the highest level of maturity, this is not commonly found in the everyday practice of urban government. However, the highest levels in the maturity model can show the transformative potential of technology and big data innovation.



Our proposed maturity model for big data in urban governance is shown in Table 1. This tool builds on a number of big data and smart city maturity models developed previously by others.<sup>29</sup>

	FUNCTIONAL COMPETENCIES				
MATURITY LEVEL	OPEN DATA	CULTIVATING DATA ECOSYSTEMS	ANALYTICS	DATA-DRIVEN DECISION-MAKING	PARTICIPATION & PUBLIC SERVICES
LEVEL 5 OPTIMIZING (SMART URBAN COLLABORATION)	Read-write platforms empower user-community curation and extension of data; governance protocols embedded in software enable responsible sharing.	Industry, academia, government, and citizens share trusted data; data marketplaces create safe, secure platform for many-to-many exchange of big urban data.	Open-analytics platforms enable rapid innovation in algorithms; production of predictive analytics is fully automated, reducing barriers to access.	The organization and its operations continuously adapt and improve using analytical insight in line with strategic policy objectives; processes that require modest human judgement are subject to potential automation.	Citizen-driven vision and governance innovation agenda; open-innovation platforms for data-driven public services; shared data-enabled governance.
LEVEL 4 ADVANCED (SMART ADMINISTRATION)	All nonsensitive data published openly, with robust data-user community support and data-set request processes exist.	Most useful data is “big”; crowdsourcing data collection widespread; external data exchange with private sector; incentives for data sharing are commonplace.	Predictive analytics is widely used to identify actions that maximize operational effectiveness and achieve policy outcomes.	Decision makers are well informed with insight from analytics, and the organization is capable of acting to maximize key performance indicators; processes that require little human judgement are automated.	Thorough citywide service integration with pockets of citizen prosumers driving service innovation; robust cross-department innovation management.
LEVEL 3 INTERMEDIATE (SMART DECISION-MAKING)	Open-data policy and regulation mandates timetable for comprehensive data disclosure, subject to security and privacy review; real-time data published when feasible.	Integrated sensor networks support multiple users; data platforms enable automated sharing; mashups from diverse sources.	Predictive analytics provide insight on the likelihood of important changes in activity patterns affecting the organization’s operations or policies.	The organization is able to make limited business decisions using analytical insight to improve operational efficiency and generate more value; data dashboards support a data-driven culture.	City-initiated vision, strategy, and implementation for data-driven participation and public services; integrated delivery platform incorporates citizen feedback loops.
LEVEL 2 BASIC (GOVERNMENT OF A SMART CITY)	Open-data portal aggregates published government data sets.	Application-specific sensor networks collect relevant data; policies for data privacy, security, and sharing established; data quality is poor; cross-linking requires time-consuming manual integration.	Analytics are used to inform decision makers about the causes and contributing factors for key processes and events in the organization’s operations.	The organization understands the causes behind what they observe, but its culture is largely resistant to adapting to take advantage of the insight.	Pockets of public services innovation, with some integration and cross-department data sharing; limited citizen engagement.
LEVEL 1 AD HOC	Data sharing enabled through scattershot regulations and departmental policy.	Agencies rely on historical data exhaust from operations; data is in silos with little sharing.	Analytics are limited to describing what has happened.	The application of analytical insight is the choice of the individual and has little effect on how the organization operates.	Little data-enabled engagement or use of data in governance or service delivery; digital public service strategies do not exist, or they exist in isolation.

**Table 1.**  
The IDB Big Urban  
Data Maturity Model



# THE MATURITY MODEL IN ACTION: ASSESSING IMPACT IN FORTALEZA, SÃO BERNARDO DO CAMPO, AND CÓRDOBA.

We recommend municipal leaders use this tool with the following goals in mind:

1

**TO ASSESS INITIAL BIG DATA CAPABILITIES ACROSS THE FULL RANGE OF FUNCTIONS AND STAKEHOLDERS INVOLVED IN URBAN GOVERNANCE.**

2

**TO ASSESS AND RECOGNIZE MATURITY MILESTONES IN INDIVIDUAL CAPABILITIES, AS THIS PROVIDES A WAY OF MEASURING WHETHER AN INITIATIVE HAS NARROW OR BROAD-REACHING IMPACTS.**

The following three case studies show how cities can apply the maturity model.

ASSESSING  
YOUR CITY'S  
COMPETENCY





## FORTALEZA BRAZIL

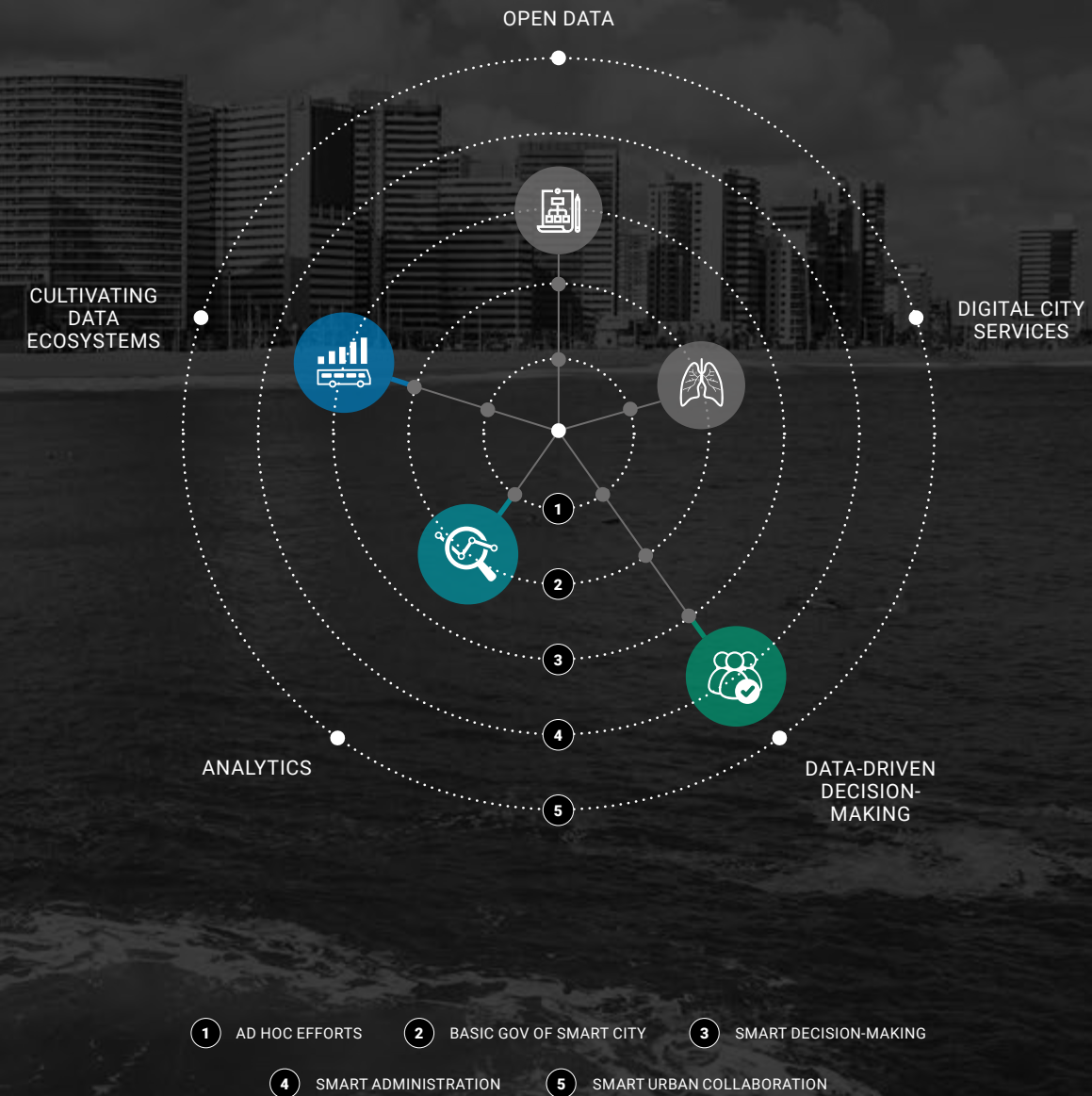
The big urban data maturity model can be used to evaluate the broader impact of specific projects and initiatives. Fortaleza, the state capital of Ceará, is the fifth largest city in Brazil and one of the two winners of the 2015 Gobernarte prize. The municipality had previously worked with partners to deploy sensor networks and data repositories to collect and store tracking data on the locations of city buses and shared bikes. These capabilities allowed for basic improvements in data sharing, understanding current conditions, and managing mobility services. These steps were essential to bringing the city to the second level of maturity in three areas: cultivating data ecosystems, analytics, and data-driven decision-making.

Three projects undertaken in 2014–15 under the *Fortaleza Inteligente* initiative leveraged Fortaleza’s existing big urban data capabilities to achieve these advances. One project used machine learning to comb through historical data on bus performance and traffic congestion and suggest route changes that improved travel times on some lines by more than 200 percent.<sup>30</sup> Another effort created a predictive-demand model to assist with the placement of new bike-share stations. Finally, the team, which included academics from the University of Fortaleza and support from the University of Arizona, delivered a web-based mobility dashboard providing a unified visualization of the transportation system performance indicators that will support long-term and day-to-day decision-making in government.



**Figure 1.** Maturity model results for Fortaleza, Brazil.

ASSESSING  
YOUR CITY'S  
COMPETENCY







## SÃO BERNARDO DO CAMPO BRAZIL

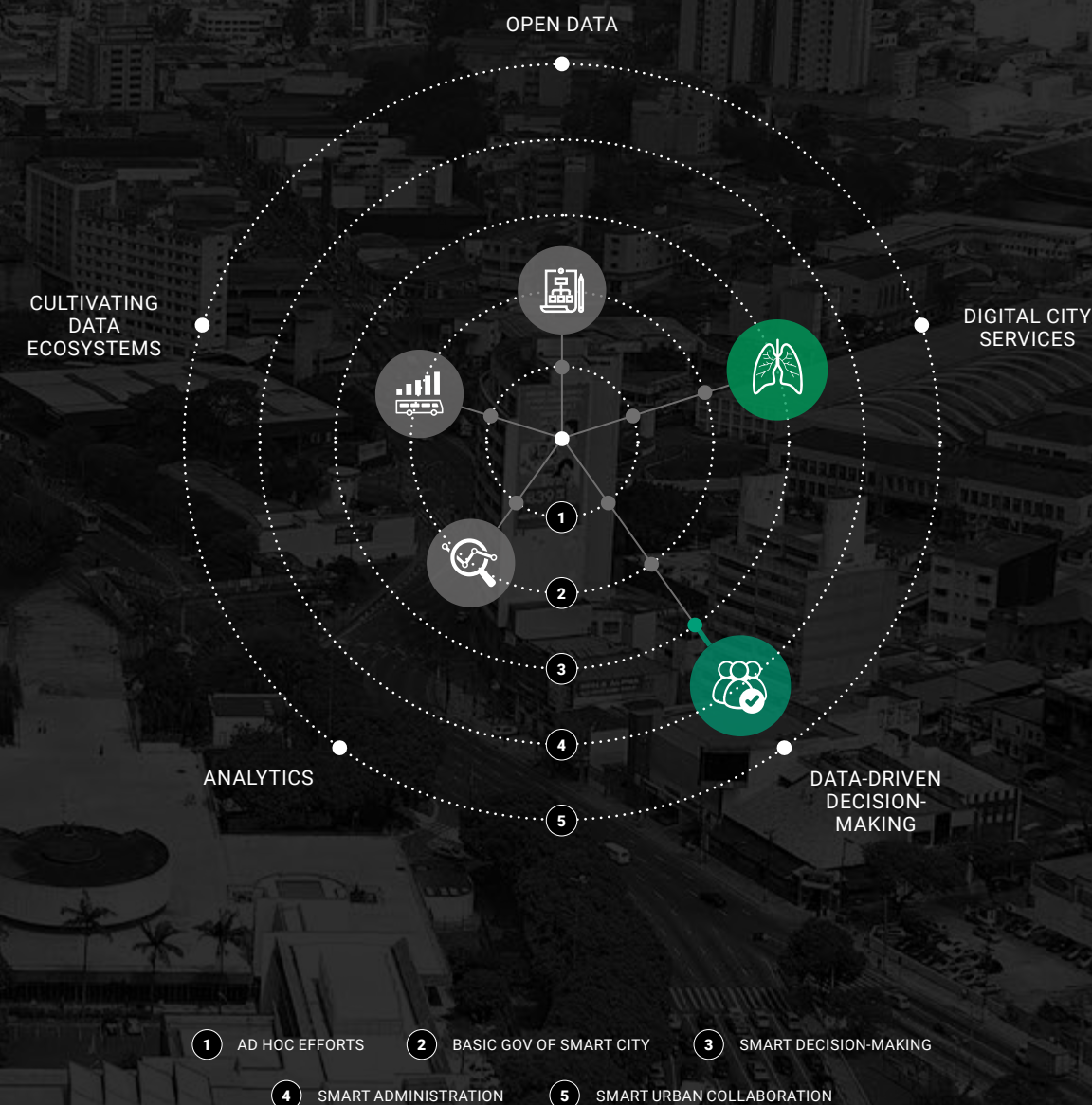
São Bernardo do Campo (SBC), a dynamic industrial city of 800,000 located in the São Paulo metropolitan region, won the 2015 Governarte Award for demonstrating how innovation in data-enabled public services and participation can set the stage for deeper reforms in urban governance. In 2015, the municipality launched VcSBC, a mobile application that allows citizens to report issues across a wide range of nonemergency services, such as potholes, garbage issues, and decaying trees. The app's transformative power resides in its capacity to centralize demand for services in a single, digital channel, allowing the municipality to allocate tasks from an integrated workflow across previously siloed departments.

The project was the result of a partnership between the municipality and the TIM Institute, which facilitated collaboration with civic technology labs to adapt existing platforms and create VcSBC's app.

VcSBC offers valuable lessons for data-oriented governance. First, the app is made possible by the municipality's recent investments in state-of-the-art IT infrastructure. These investments came with the recruitment of experienced talent in programming and data analysis. Second, through the partnership with TIM, VcSBC harnessed the power of open-source applications. This approach effectively connected municipal staff with other actors in the broader São Paulo data ecosystem, allowing them to pilot and improve on civic technologies that can easily be deployed elsewhere. By investing in people and systems, and promoting partnerships with civil society, the municipality took an important step toward full digitalization of municipal services better able to respond to citizen need.



**Figure 2.** Maturity model results for São Bernardo do Campo, Brazil.







## CÓRDOBA ARGENTINA

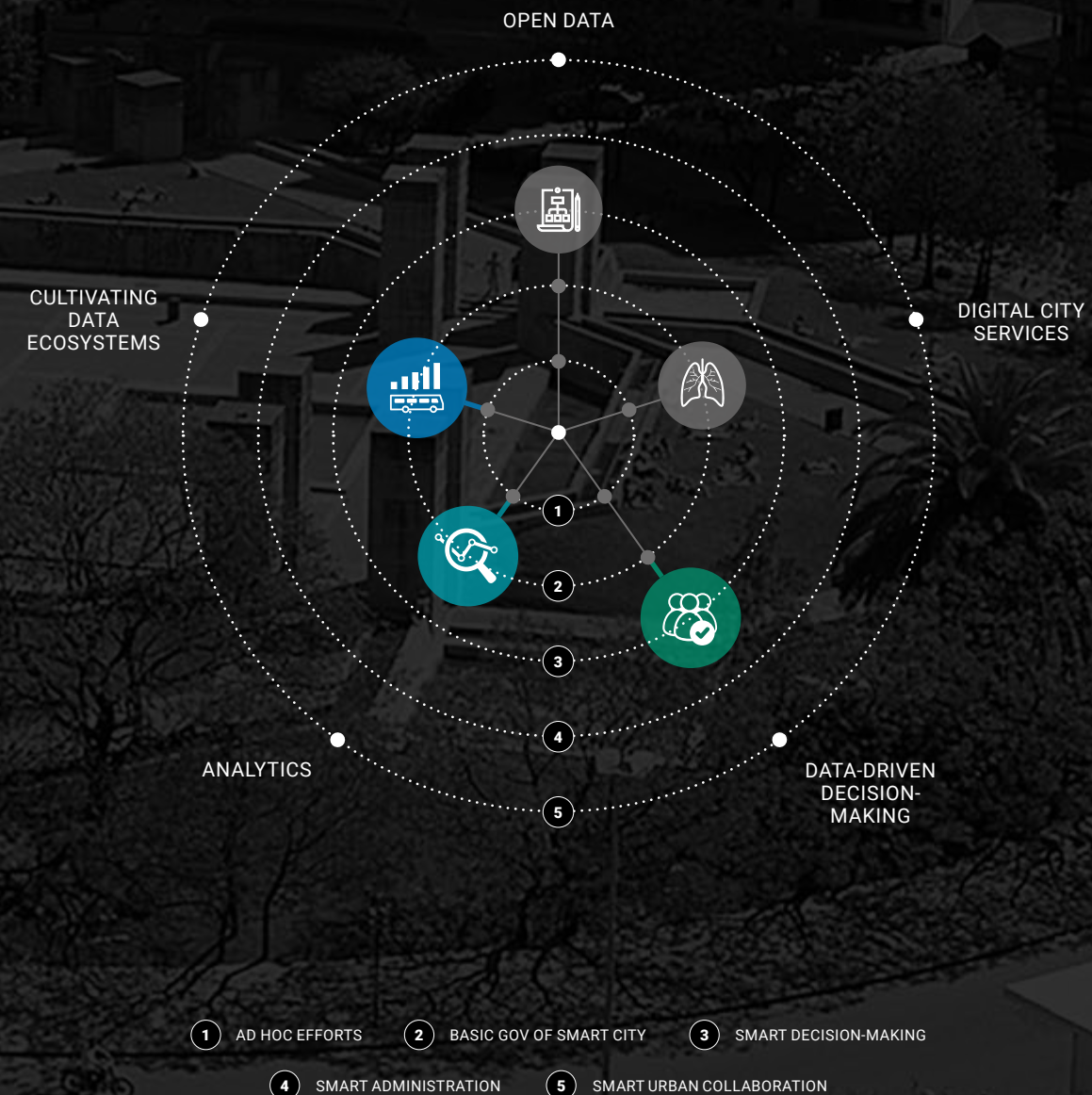
Córdoba's is a tale of two tracking systems. Public bus services in Argentina's second-largest city—and runner-up in the 2015 Gobernarte Awards—operate under contract by private operators. One of these operators began to track its buses in 2007 and launched an app (cuandollega.net) and a network of real-time arrival signs at key stops. By 2012, it had become clear to city officials that not only was it important to expand these services to the lines served by other private operators, but that there was a need for an independent, universal source of public transport data. And so, under the *Sistema de Monitoreo de flota del Sistema Público (SMSP)* project, the city mandated the installation of a dedicated GPS device

to transmit bus locations directly to a new city-data platform. As a result, today privately operated buses have two tracking systems—the company's and the city's.

The project highlights the complex issues that cities can face when working with heavy-hitting private companies often found operating infrastructure in Latin America. “Sensor sprawl”—the deployment of overlapping, sometimes redundant, and sometimes conflicting data-acquisition infrastructure—is a common growing pain of the big data maturation process, the result of multiple stakeholders pursuing big data efforts with limited coordination and over a wide geographic area (the spread of CCTV in recent decades, for instance, is a classic example of sensor sprawl).



**Figure 3.** Maturity model results for Córdoba, Argentina.







Why not simply mandate a common reporting frequency and format and allow the operators to use their existing GPS tracking equipment? From a technical perspective, this kind of data integration is certainly feasible. But such an approach would come with many initial and ongoing soft costs in time and effort, most of which would be borne by the city. Deploying an additional tracking unit to each bus and offloading the cost of compliance to the operators allowed the city to begin collecting data sooner and at far lower cost to the city

(the entire project, in fact, had a relatively small budget of just \$500,000).

While it might seem redundant, the new city-owned system has strategic importance. With its own fleet of data infrastructure securely in place and operating reliably (run in-house through an agreement with a global technology solutions company), the city is now able to pursue long-term planning projects with the assurance that data access and continuity will not be jeopardized in the future due to changes in individual contracts.

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28. Albert Meijer and Manuel Pedro Rodríguez Bolívar, 2016. "Governing the Smart City: A Review of the Literature on Smart Urban Governance," *International Review of Administrative Sciences* 82, no. 2 (2016): 392–408.

29. Bahjat El-Darwiche, Volkmar Koch, David Meer, Ramez T. Shehadi, Walid Tohme, "Big Data Maturity: An Action Plan for Policymakers and Executives," in *The Global Information Technology Report*, 2014; Wiseman, Wiseman, "Analytics Excellence Roadmap"; "Two Innovative Toolsets," Digital Dublin Blog, accessed June 3, 2019, <https://digitaldublin.wordpress.com/two-innovative-toolsets>.

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# 04

**BID URBAN DATA**  
A Strategic Guide for Cities

# ACCELERATING CHANGE WITH URBAN DATA:

**INSTITUTIONAL RECOMMENDATIONS**

1 | 2 | 3 | 4 | 5

The opportunity for big data is quickly coming within reach of cities in the LAC region. Our primary contribution in this report is to clarify the path to big urban data maturity. While this evolution will be marked by significant obstacles and periodic setbacks, we believe the big urban data maturity model can provide an ongoing reference point to keep strategy aligned with a clear and desirable long-term vision.

In this section, we further flesh out how a typical LAC city might progress toward big urban data maturity and provide a focused set of recommendations for leaders and practitioners.

First, we have curated a selection of tactics and initiatives from around the world that LAC cities can draw on and adapt locally to reprogram government and advance toward data maturity in the five competencies.

A second set of recommendations is more strategic, dealing with how cities can create capacity to institutionalize successful big data innovations: by generating revenue, by designating leadership, and by adopting rules and norms that establish democratic authority for data innovation.



## REPROGRAMMING GOVERNMENT: TACTICS AND INITIATIVES FOR INSTITUTIONAL CHANGE

The first set of recommendations details specific actions, tactics, and initiatives for achieving big data maturity, level by level, *inside government*, across the five functional categories in the model: open data, cultivating data ecosystems, analytics, data-driven decision-making, and participation and public services. This is a playbook for cities, drawn from what has worked throughout the LAC region and beyond, that cities can use to as a starting point for generating ideas and designing their own campaigns.

### OPEN DATA

The open-data maturity process can begin with *ad hoc* data sharing initiated in pioneering government departments. The next steps would entail making this data open to the public and the eventual development of a single stop portal that aggregates existing publicly available datasets. This typically involves a thorough internal data source assessment and preparation process. Numerous guides to help cities plan this step are available.<sup>31</sup>

As a city moves from basic to middle levels of maturity, it should adopt comprehensive open-data regulations that mandate a timetable for disclosing all nonsensitive data, such as New York City's Local Law 11 (2012).<sup>32</sup> Real-time data should be published when available and subject to reporting delays to ensure quality. In addition, robust tools and support services should be provided for the data-user

community. For instance, in 2017 New York City's Department of City Planning established NYC Planning Labs, a dedicated team of developers that create web-based tools for working the city's vast repositories of parcel, land use, and infrastructure data; in 2013, Singapore's Urban Redevelopment Authority similarly created a digital planning lab. Data-request procedures that supplement or augment existing "sunshine" laws (which require that government proceedings be open and public) are also essential.

As open-government data platforms evolve and move to higher levels of maturity, they should facilitate the aggregation of data streams from the broader community of data suppliers and users focused on the urban region. For instance, Data Mill North in the English city of Leeds features data sets from both private-sector partners as well as affiliated government bodies beyond the municipality itself.<sup>33</sup>



## CULTIVATING DATA ECOSYSTEMS

Open-data initiatives work hand in hand with a broader set of stakeholder networks, practices, and sources driving the effective use of data in urban governance—the urban data ecosystem.

The seed for urban data ecosystems is exhaustive data from government operations. As the owners of this data discover opportunities and develop their own appetite for data exchange, clear guidelines for data privacy, security, and sharing within government agencies should be established. At first, these internal exchanges may be hindered by the limited scope and poor quality of existing data and the need for time-consuming manual integration. Over time, cities should deploy data platforms that enable automated sharing and should take advantage of mash-ups from diverse sources, like New York City's DataBridge, which integrates more than 50 real-time data feeds from 20 agencies and external organizations.<sup>34</sup>

Data ecosystems also require investments in data literacy that generate demand for data and the ability to use it as a tool for innovation. Cities should

support the development of data-ecosystem curators and data intermediaries such as University of Chicago's Data Science for Social Good, which offers training to aspiring data scientists on projects with a clear social impact, and DataKind, which provides technical assistance around big data to nongovernmental organizations.<sup>35</sup>

A fully mature urban data ecosystem is equipped to wrangle big data at all stages and across all components. Steps must be taken to expand data collection in any area where coverage is insufficient to inform decision-making; this may include the deployment of new sensor networks. While this deployment may initially focus on application-specific sensor networks, over time, integrated sensor networks supporting multiple users become critical. At full maturity, crowdsourcing data collection is widespread, and both incentives and platforms for data exchange with the private sector are commonplace. One approach that should be explored is Copenhagen's data marketplace, the City Data Exchange, currently being developed, which will allow industry, academia, government, and citizens to share or sell trusted data.<sup>36</sup> Such data marketplaces should create safe, secure platforms for many-to-many exchange of big urban data.







## ANALYTICS

At low levels of maturity, analytics are typically limited to describing what has happened (descriptive statistics). As a city's maturity level increases, analytics can shed light on the underlying causes of major events and, as these models are tested and calibrated, make predictions about the future. This predictive ability allows officials to anticipate changes ahead of time or simulate the impacts of policy alternatives.

Rapid advances in machine learning and artificial intelligence techniques and in the exponentially growing abundance of computing power begin to define the opportunity at the highest levels of maturity. At these advanced and optimal levels, predictive analytics are expected to become progressively more capable, and as trust and familiarity grow, they should be used widely to guide decisions that determine operational effectiveness and policy outcomes.

Collaboration with outside researchers should be a major component of cities' big data innovation strategies. Cities should establish with universities

research-policy partnerships that provide both immediate value to public officials while also being scientifically relevant. Note that cities should avoid the common practice of treating faculty and students as free consulting resources.

However, other open-analytics models that leverage open-source collaboration frameworks are being developed, and this may be an appealing model in many instances. The City of Chicago, for instance, used the GitHub open-source software collaboration platform to facilitate development of its celebrated food-safety analytics tool.<sup>37</sup> In early 2017, IDB launched the regional platform Code for Development, which allows city leaders, civil society, academia, and private-sector actors to explore and reuse open-source digital tools in support of economic and social development throughout the LAC region. This makes the IDB the first multilateral development agency to formally recognize open code as a knowledge product. Code for Development connects to GitHub repositories and has recently added newly created open-source applications for participatory mapping, field-data collection, and automated urban-land-use classification.<sup>38</sup>



## DATA-DRIVEN DECISION-MAKING

Creating a culture of governance that can use data to improve decision-making is a fundamental challenge to big data maturity.

At first, analytical insight is limited to individual innovators and has little effect on organization-wide decisions. As the organization matures, it may come to acknowledge, value, and seek these analytics but still possess significant internal barriers to taking advantage of the results.

At a mid-level maturity level, urban governments embrace performance dashboards, which operationalize a basic culture of data-driven decision-making. The use of data in decisions is still limited but not unfamiliar.

At the highest levels of maturity, decision makers are well informed with insight from analytics, and the organization deliberately acts to maximize key performance indicators. The organization and its operations continuously adapt and improve using analytical insight in line with strategic policy objectives. Finally, automation begins to play a major role—augmenting at first, but potentially supplanting some simple human decision-making processes.



## DIGITAL PUBLIC SERVICES

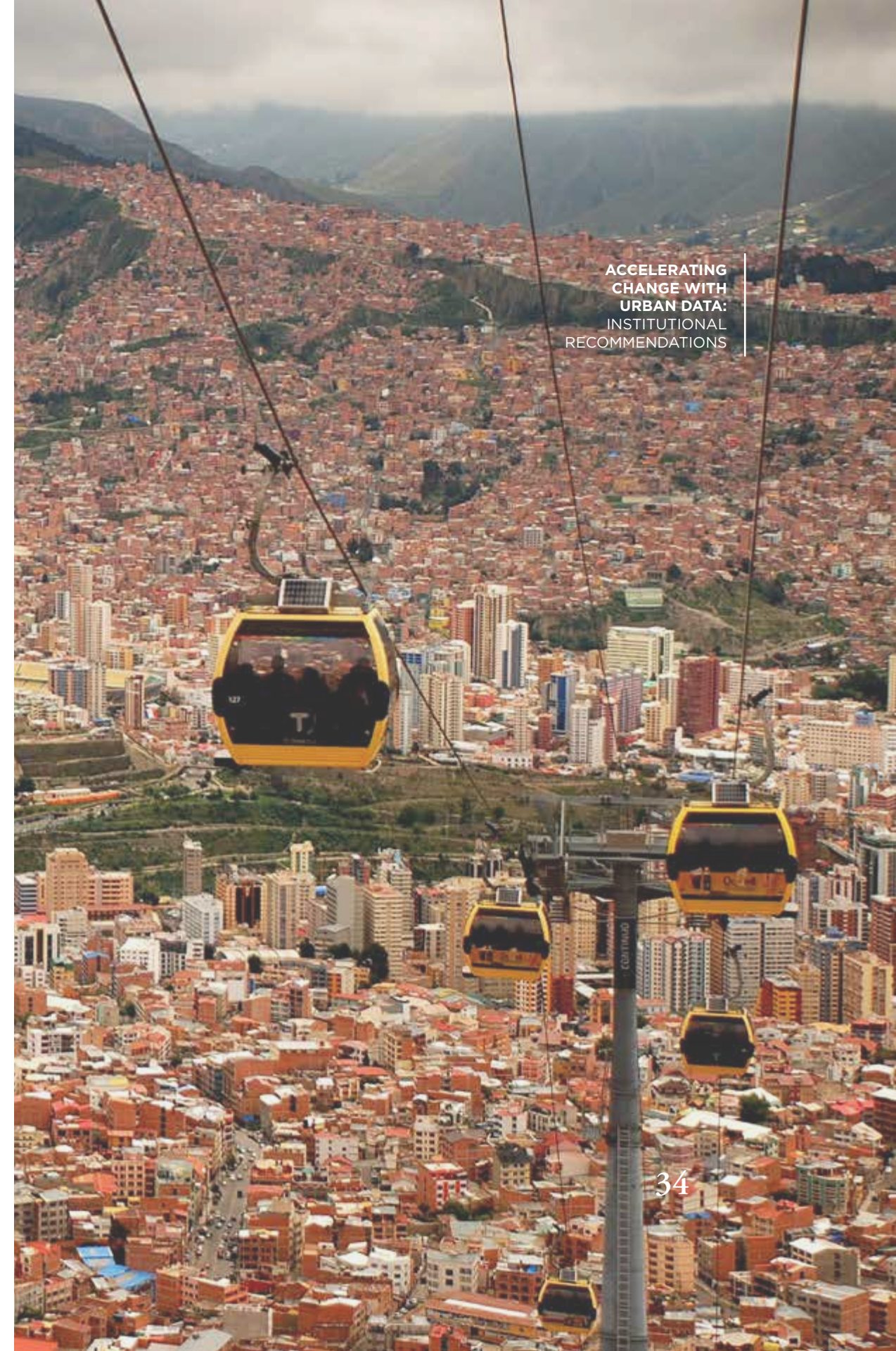
The delivery of public services and citizen participation in governance are areas where improved decision-making based on big urban data can have the most substantial value. Benefits accrue here from increasing levels of engagement as well as from strategically coordinated innovation across government agencies.

At the lowest levels of maturity, cities exhibit little tech-enabled engagement or use of data in governance for service delivery. Examples of digital public service strategies are difficult to find. However, as big data maturity develops, more pockets of public service innovation should

be encouraged, with growing attention to integration and cross-departmental data sharing. Citizen engagement efforts should focus on effectiveness and transparency, with smaller user groups to maximize impact and relevance.

Reaching higher levels of maturity requires thorough integration of services citywide, with community-based organizations driving service innovation. Mid-level maturity is typically marked by the emergence of city-initiated vision, strategy, and implementation for data-driven participation and public services. Ultimately, this should lead to articulation of a citizen-driven vision and governance innovation agenda. An integrated delivery platform should enable citizen feedback loops. Innovation should be managed in an open, robust way that cuts across departmental barriers and engages the public substantially.

ACCELERATING  
CHANGE WITH  
URBAN DATA:  
INSTITUTIONAL  
RECOMMENDATIONS







## CREATING SUSTAINABLE URBAN DATA PLATFORMS

Our second set of recommendations is about improving capacity for big urban data innovation by creating platforms that connect assets inside and outside government.

These recommendations recognize that it is not enough to simply understand the development targets for each level of big urban data maturity. It is equally important to understand how these innovations are produced, and how they are successfully institutionalized by securing the financial, human, and regulatory capacity to sustain operations.



# THE BIG URBAN DATA INNOVATION PROCESS

To better equip ourselves to understand how big data approaches are conceived and delivered within both the existing internal institutional and external stakeholder contexts of a big city government, we developed a conceptual model of the life cycle of innovations for big urban data initiatives. This life-cycle model is adapted from the Urban Institute's 2016 publication *A Political Economy Framework for the Urban Data Revolution*. We expanded on this model by showing how the catalysts and inputs to big data innovation are organized and institutionalized, and made further recommendations for how cities can increase their capacity to drive projects along each step of the process.

Big urban data innovation consists of six steps, each of which is enabled by multiple functional categories of the maturity model:

ACCELERATING  
CHANGE WITH  
URBAN DATA:  
INSTITUTIONAL  
RECOMMENDATIONS



## STEP ONE IS SEEDING CAPABILITIES AND PRIORITIES

Because the need for big data often arises suddenly, considerable effort should be devoted to proactively building capacity in the urban data ecosystem and to establishing and signaling priorities on means (open data, privacy and ethics of data use, etc.) and ends (sustainability, equity, etc.) of data innovation.

## STEP TWO IS PROBLEM IDENTIFICATION AND EXTERNAL DATA SUPP

Participation should be expanded as widely as possible to level the playing field for disadvantaged stakeholders and for relevant outside data should be mobilized, analyzed, and validated. This approach can avoid a politically contentious prioritization of issues. Organizations and activities involved in seeding capabilities and priorities may contribute to one or more of these processes if made in a participatory way.

## STEP THREE IS SECURING INTERNAL ACCESS

The biggest barriers to data sharing often exist *within* government, both between levels and across agencies. Before collecting new data, cities must overcome obstacles and disputes to access existing data relevant to the problem at hand. This may involve creative approaches to valuing data assets and incentivizing data holders to release them.

## STEP FOUR IS ANALYSIS AND INSIGHT GENERATION

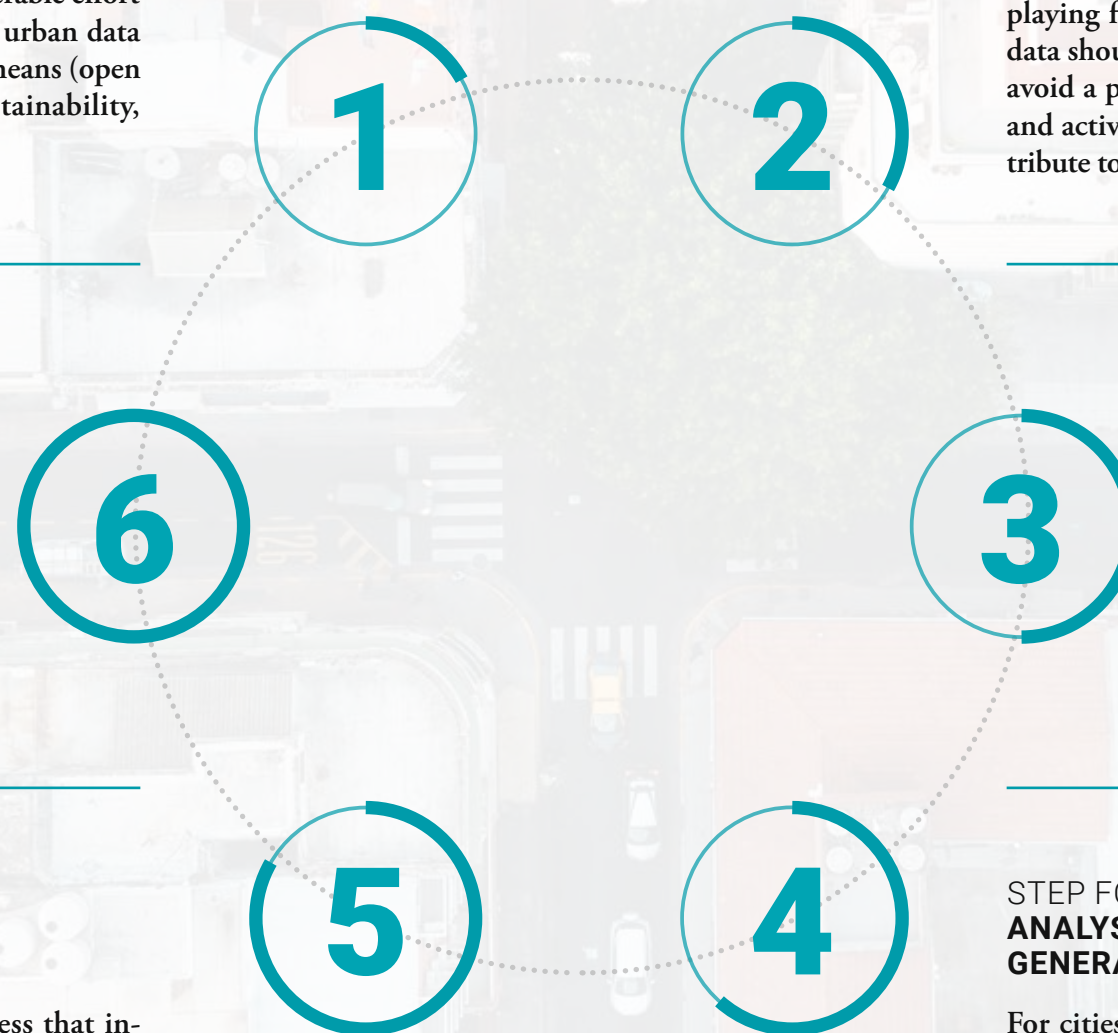
For cities to gain the analytic capacity for most truly big data, they must identify and acquire data science skills, infrastructure, and domain expertise knowledge across government agencies and complement this through external partnerships with university researchers, private firms, and civic organizations. The results of this analysis must be translated into communicable insights, often requiring a very different set of skills from the initial analysis.

## STEP FIVE IS DECISION-MAKING AND ACTION

This involves creating and managing a deliberative process that incorporates the insights of big data analysis. This means verifying the accuracy of input data (complementing these actions from step two), establishing the credibility of the analysis, and feeding insights into the decision-making process at appropriate times. Cities must also put in place mechanisms to monitor performance and adjust policy implementation accordingly over time.

## STEP SIX IS INSTITUTIONALIZATION.

This requires successful big data innovation projects to be evaluated and prioritized for long-term planning to ensure sustainability. We expand on this step in the next subsection by looking at three avenues of institutionalization—self-financing strategies for big urban data, leadership roles for innovation, and enabling regulation.





Together with the *big urban data maturity model*, this process framework provides a tool for disaggregating big urban data governance initiatives into smaller pieces and assessing their relative significance or effectiveness. It also provides a tool for examining the role of public participation at each step. Traditionally, demands for wider external participation in government innovation projects come during steps one and

two, but as open data makes it easier for outsiders to do valuable analysis and evaluation in parallel, it creates interesting opportunities for greater participation throughout the entire process. This, however, will create greater challenges for the institutionalization of processes that must integrate internal and external functions at multiple points of within already highly complex municipal organizations.





# AVENUES FOR LONG-TERM INSTITUTIONALIZATION

The most challenging and risky step in the big urban data innovation process is institutionalization. It is here that projects can fail in many ways on account of inflated ambitions, inability to scale, compromises that undermine the core value of the innovation, and so on. Three avenues to countering these challenges are securing financing, designating leadership, and establishing democratic authority.

## 1 SECURING FINANCING

Securing financing for innovation projects, let alone technology-intensive ones, is a widespread, ongoing challenge for city governments globally. For much of the last decade of the smart cities movement, little

serious attention has been paid to the challenges of financing investments in digital technology. But this is changing quickly, as stakeholders across the public and private sectors recognize the seriousness of this situation. For instance, technology manufacturing giant Siemens recently tapped the expertise in its own financial services division to help bring attention and fresh thinking to the problem. The company's report explains, "There is broad recognition across the globe that taxation revenues are already overstretched simply to fund the public sector's *operational* expenditure" (emphasis in the original).<sup>39</sup>

Big data innovation in urban government certainly shares a similar challenge to smart infrastructure investments of the kind the Siemens report considers. But as they tend to be much less capital-intensive—for instance, setting up an open-data portal may require little else besides dedicated staff hours for scraping, analysis, programming, and design—and have much shorter deployment timelines, big data innovations have high potential to be financially sustainable.

A variety of possible revenue models that are widely used in the private sector by big data start-ups are presented in Table 2, along with examples of companies focused on big urban data specifically. This framework is based on a 2014 study of big data business models by Cambridge Service Alliance, an industry-university research partnership.<sup>40</sup> While additional development is needed to translate these strategies into models that could be implemented within city governments on a permanent basis, they suggest clear paths to institutionalization by reducing or eliminating the financial burden of these programs on existing budgets.

This disposition to financial sustainability is part of big data's potential, but also part of its great risk in the public sector. Dollar signs can hide dangerous flaws in the bias, privacy controls, or policy influences of poorly designed big data initiatives. Yet as municipal governments face a growing array of demands for delivery of services and continuous innovation amid an increasingly challenging set of revenue-generating tools, this is one possible path forward.



REVENUE MODEL	DESCRIPTION	URBAN DATA ASSETS	REVENUE SOURCES	DATA-DRIVEN DECISION-MAKING
FREE DATA COLLECTOR AND AGGREGATOR	Aggregate and visualize data from a vast number of different, mostly free available data sources.	Open government data (general) Social media	Advertising Software/platform licensing fees Subscription fees	Socrata TransportAPI Appallicious Roadify Milieu
ANALYTICS AS A SERVICE	Conduct analytics on data provided by their customers.	Capital asset inventory and logs Operational logs and forms incident reports	Platform licensing fees Custom deployments Subscriptions	GSA AAAS Timbr.io One Concern MuniRent
DATA GENERATION AND ANALYSIS	Generate data themselves— often through deployment of new sensors—rather than relying on existing data. Most of the companies also perform analytics on this data.	Location logs of people and assets Satellite and aerial imagery Infrastructure and embedded system logs Environmental conditions	Data licensing Subscription fees In-kind data exchange IP licensing fees	Waze Connected Citizens Planet Labs Strava Ayyeka Everimpact
DATA AGGREGATION-AS A SERVICE	Aggregate, index, document, and package data from multiple internal sources for their customers.	Operational data administrative records Budget and fiscal data	Software/platform licensing fees	Munisense Mark43 Logikcull OpenGov
FREE DATA DISCOVERY, MASHUP, AND ANALYSIS	Aggregate data provided by customers, with other external, mostly free, available data sources and perform analytics on this data; external data sources are used to enrich or benchmark customer data.	Public-property records Utility operations Market data Open-government data Demographic, economic baseline data	Software/platform licensing fees Commissions on transaction recommendations	SmartProcure Urban Engines Transitmix AirSage Azavea

**Table2.**  
Urban Data  
Revenue Models



## 2 DESIGNATING LEADERSHIP

Designating leadership around innovation is a critical step to enabling a culture of data-driven governance. Cities around the world are creating new leadership positions to build data capabilities:

**1** *Chief technology officers* see data as a central component of a broader digitalization strategy incorporating broadband and other technology infrastructure, citizen engagement, and tech-sector economic development; Chicago's CTO position offers an example.

**2** *Chief data officers* typically focus on identifying stakeholders in city departments with data assets and, as leaders, can encourage data sharing for experimental analytics. They primarily serve as demonstrators and developers of rapid-policy-analysis and program-evaluation tools. In recent years, LAC countries have named national-level officers and directors, such as Gonzalo Iglesias, national

director of data and public information for Argentina. Only a handful of cities, such as Bahia Blanca, Argentina; Rio de Janeiro, Brazil; Medellin, Colombia; Mexico City, Mexico; and Quito, Ecuador, have created municipal agencies whose leaders have the potential to act as full-fledged CDOs but who do not yet have the institutional authority and rank of other departmental authorities.<sup>41</sup>

**3** *Chief innovation officers* focus on building capacity and developing processes for sourcing solutions to government challenges and often become advocates for data because of its ability to support fast, ad hoc, high-value, capital-light innovation (e.g., San Francisco, São Paulo)

**4** *Digital services officers*<sup>42</sup> create capacity for data delivery in the form of services, by putting in place design standards and infrastructure that reduce costs and time and improve the quality of digital government services. The role was pioneered at the national level in the UK and later adopted in the US; it is now being tested in San Francisco.<sup>43</sup>

**5** More recently, the US city of Detroit created the role of *Digital inclusion officer*, whose mandate is to expand access to technology for low-income communities.<sup>44</sup> This position stands out for its targeted focus on low-income communities, as well as for its emphasis on academic and business partnerships as a way to deliver digital services.





At the lowest levels of maturity, cities may be able to support only a single big data advocate role. Cities should seek an advocate, a maverick even, who sees data as a passion and is willing to stake their career on advancing the agenda to the next stage. Over time, cities can add capacity to broaden and strengthen a data-driven innovation and technology agenda.

The key challenge is sustaining successes across changes in political leadership. This may require a different kind of talent, a person able to engage some institutional stakeholders and co-opt or subvert others to maintain continuity in a big data innovation agenda. Once data advocates assume a more leading role, two longer-term challenges are planning, mobilizing support for, and implementing large-scale reforms, as well as identifying and implementing sustainable fiscal models (discussed in the previous section) that can bake big data programs into the DNA of urban government.



### 3 ESTABLISHING DEMOCRATIC AUTHORITY

Establishing democratic authority for innovations and innovators can be achieved through the design and implementation of rules, regulations, and norms. While a thorough examination of the appropriate regulatory reforms needed to advance big urban data is beyond the scope of this report, below are some important areas for action.

Legislation that compels government agencies to release open data is one essential step. New York City's Local Law 11, passed in 2012 and amended in 2015, is a comprehensive model that mandates a data-holdings assessment process for all branches of government, a framework for assessing data sensitivity and security risks, and a timetable for the release

of nonsensitive data. Procurement procedures, often put in place to improve transparency, can create undesirable obstacles to timely acquisition of data or ongoing nonfinancial data transactions.

Regarding privacy, the European Union's General Data Protection Regulation (GDPR), which came into effect in May 2018, has broken ground as one of the first comprehensive standards for the collection and management of citizens' data. GDPR requires companies to 1) anonymize collected data to protect privacy; 2) provide data breach notifications; 3) safely handle the transfer of data across borders; and 4) appoint data protection officers to oversee compliance.

Finally, unplanned overlaps between different regulations— notably, cybersecurity statutes such as those that IDB has identified as a high priority in the LAC region—must be assessed in order to reduce undue interference or disincentives to data sharing in the name of innovation.<sup>45</sup>



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31. See for instance, “Open Data: Getting Starting Guide,” GovEx, Johns Hopkins University Center for Government Excellence, accessed April 15, 2019, <https://govex.jhu.edu/open-data-getting-started-guide>.

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36. Sarah Wray, “City of Copenhagen Launches Data Marketplace,” *Inform*, May 2016, <http://inform.tmforum.org/strategic-programs-2/open-digital/2016/05/city-of-copenhagen-launches-data-marketplace>.

37. The code is available at <https://github.com/Chicago/food-inspections-evaluation>, accessed June 3, 2019.

38. “Code for Development,” Inter-American Development Bank, accessed June 3, 2019, <https://code.iadb.org>. For more details on the launch of the platform, see <https://blogs.iadb.org/conocimiento-abierto/en/the-idb-is-committed-to-the-open-source-model-for-development>.

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40. Philipp Max Hartmann, Mohamed Zaki, Niels Feldmann, and Andy Neely, “Big Data for Big Business?: A Taxonomy of Data-Driven Business Models Used by Start-Up Firms” (working paper, Cambridge Service Alliance, University of Cambridge, UK, 2014).

41. For a representative list of chief data officers in the United States, see “Who Are America’s City Chief Data Officers?,” Data-Smart City Solutions, Ash Center for Democratic Governance and Innovation, Harvard Kennedy School, January 24, 2019, accessed April 15, 2019, <https://datasmart.ash.harvard.edu/news/article/data-leadership-at-the-executive-level-761>.

42. Joy Bonaguro, “We Want You—Serve as the Digital Services Chief for San Francisco,” DataSF (blog post), updated July 26, 2016, accessed April 15, 2019, <https://datasf.org/blog/we-want-you-serve-as-the-digital-services-chief>.

43. Joy Bonaguro, “We Want You—Serve as the Digital Services Chief for San Francisco,” DataSF (blog post), updated July 26, 2016, accessed April 15, 2019, <https://datasf.org/blog/we-want-you-serve-as-the-digital-services-chief>.

44. Jonathan Andrews, “Detroit hires director of digital inclusion,” *Cities Today*, April 16, 2019, <https://cities-today.com/detroit-hires-director-of-digital-inclusion>.

45. *Cybersecurity: Are We Ready in Latin America and the Caribbean?* (Washington, DC: Inter-American Development Bank and the Organization of American States, 2016).





# CONCLUSIONS

This technical note is a contribution to the efforts to plan for the two phenomena that will come to define development in the 21st century: the digital revolution and rapid urbanization. Our specific focus is on the central role *big urban data* can play in urban governance. We recognize that big data is the primary resource that powers our era's digital transformation. Mass collection, analysis, and use of data is central to private-sector growth and innovation today, including cutting-edge analytical processes such as artificial intelligence that will come to dominate many aspects of our economies. Considering that in a context of rapid urbanization and digitalization most of this information is generated and used in cities, the question is whether data-driven growth and innovation can be directed by and benefit citizens at large.



When applied to the otherwise routine delivery of urban infrastructure and services, big urban data has been shown to improve efficiency and quality. Our analysis of programs from a wide range of global cities, including case studies from Latin American and Caribbean cities featured in previous IDB research and publications, points to performance improvements in sectors such as transportation, health, and citizen security, among others. However, risks abound, from the potential to embed discriminatory practices into seemingly neutral analytical tools, to the invasion of privacy through the collection of personal, identifiable data, to the growing capacity for authorities to monitor and control its citizenry. With a few companies and state actors now commanding exclusive control over growing quantities of data, *knowledge* inequality is as present a risk as income inequality. Given these benefits and drawbacks, we believe city governments in Latin America and the Caribbean, as well as in other developing regions, need tools that can help them define clear strategies and goals around the democratic use of big urban data.

To this end, the big urban data maturity model introduced in this note can help cities assess their readiness for data-enabled urban governance. Municipalities can use this model to identify where they currently stand in five institutional competencies—open data, data ecosystems, analytics, data-driven decision-making, and digital city services—and can also gain an understanding of the steps they need to achieve higher maturity levels.

Even as municipalities incorporate the big urban data maturity model into their planning exercises, there are complementary strategic actions they can take to enable data-driven governance. Municipalities can take a big leap forward by learning from and adapting some of the innovative revenue models currently used in different cities around the world. In addition, we have listed examples of recent and effective leadership positions created inside city governments to support data innovation and inclusion, as well as critical areas to consider regarding regulatory and normative reforms.

When applying these tools and strategies, municipal leaders and citizens will note that higher levels of maturity correspond to more open, accessible, and democratic technological and political systems. We have also placed special emphasis on those characteristics that make data innovations in Latin America and the Caribbean unique: a growing commitment to open data and a historic push for the “coproduction” of urban services. In this sense, our work builds on a long-standing tradition in the study of technology that reminds us that citizens can and must reclaim democratic control over technological systems—before they control us.<sup>46</sup> As political theorist Langdon Winner reflected back in 1977, “The changes and disruptions that an evolving technology repeatedly caused in modern life were accepted as given or inevitable simply because no one bothered to ask whether there were other possibilities.”<sup>47</sup> In the era of big urban data, we invite cities to explore all possibilities.



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46. See, for example, Lewis Mumford, L. 1934, *Technics and Civilization* (Chicago: University of Chicago Press, 1934); Jürgen Habermas, "Technology and Science as Ideology," *Toward a Rational Society* (Boston: Beacon Press, 81-122); Merritt Roe Smith and Leo Marx, eds., Smith, M. and Marx. L. 1994, *Does Technology Drive History?: The Dilemma of Technological Determinism* (Cambridge, MA: MIT Press, 1994).

47. Langdon Winner, *Autonomous Technology: Technics-out-of-Control as a Theme in Political Thought* (Cambridge, MA: MIT Press, 1977).





